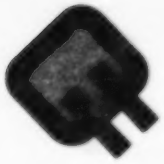

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ATIKOKAN EXPERIMENTAL NETTING INVESTIGATION 1981 AND 1982

Report No 83-443-K

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ABSTRACT

An experimental netting program to determine which fishing gear types were most effective in the live capture of northern pike, walleye and coregonids was conducted in the vicinity of Atikokan during 1981 and 1982. The results of these studies suggest that short-term set gill nets are most appropriate for live fish sampling in this area. Gill nets caught a greater number and selection of fish than did other gear types tested, while maintaining a comparable mortality rate. A literature review of various types of fishing gear and their potential usefulness in inland lakes is also presented.

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To Mr. F.J. Kee
Director of Research

ATIKOKAN EXPERIMENTAL NETTING INVESTIGATION 1981 AND 1982

O.B. Turczyn

INTRODUCTION

As part of the pre-operational biological surveys at Atikokan GS, a tagging study of northern pike, walleye and coregonids was proposed. In order for such a study to be fully successful, substantial numbers of live fish have to be collected for tagging and release. It was originally proposed that fish be collected by trap net as most fish caught in this manner are captured unharmed. However, it quickly became apparent that the trap nets did not catch as many of the target species as required, and frequently those which were caught were gilled in the lead of the trap and subsequently died. Consequently, a study was initiated to compare the effectiveness of conventional fishing gear in the live capture of commercially or recreationally important fish species typical of northern Ontario inland lakes as a basis for the selection of appropriate fishing gear for subsequent studies at Atikokan and other inland lakes.

In order to effectively catch fish, it is necessary to know when, where and why a given species may be susceptible to a particular type of fishing gear. This information will vary given any part of the year or day. A short review of life history, habitat and behavior for each of the species of importance at Atikokan, walleye, northern pike and two coregonids, is presented in Appendix 1 as an important consideration in the choice of appropriate collection gear.

A literature review of fishing gear was also conducted to determine the most appropriate type for the live capture of fish in inland lakes (Appendix 2). The applicability of several gear types are compared in Table 1. The cost, preparation time, effectiveness, limitations and suitability of the various gear types in relation to the target species in the Atikokan area is -

TABLE 1

SUMMARY OF COSTS AND EFFECTIVENESS OF VARIOUS COLLECTING GEAR

Gear	Cost	Preparation Time	Effectiveness of Gear	Limitations	Operational Cost Per Sampling	Suitability of Gear in Relation to Target Species in Study Area	Subjective Opinion as to Suitability of Gear Type to Athabasca Study Area
Electroshocker	$3000-7000	1/2 - 1 h/lake	- best suited for shallow and/or moving waters, as well as surface swimming fish - can cover large areas in short time - variability in effect due to physical conditions, fish species and size, and experience of operator	- not effective beyond 2 m depth - not as effective in open waters - operation requires relatively calm waters - need sufficient space and depth for boat access - potentially hazardous	- most labour intensive gear, may require third person - variable success	- best suited during spawning periods - could be used in small bays	- limited application
Trap Nets Hoop Nets Fyke Nets	$650/set	minimal (requires site selection)	- most effective in areas of little natural cover - fish usually captured unharmed - catch may be enhanced by baiting - greatest catch potential during spawning periods	- seasonal fluctuations in catch - requires flat, clear bottom for set - selective for fish size - not suited for irregular lake bottoms - species selective	- least labour intensive - variable results	- the morphology of lake bottoms limits the number of sites suitable for setting - limited success during spawning periods	- negative - may have limited application in channels during spawning
Trammel Nets	$150-260/set	minimal	- can be used in wide variety of situations - portable, simple to use	- size selective dependent on mesh size - fish seldom captured unharmed - highly visible due to large amount of mesh used - takes longer (2x) to work than gill net	- labour intensity directly related to numbers of fish caught - more (2 times) labour intensive than gill nets due to large amount of mesh present (more tangles)	- fish seldom caught unharmed - visibility may be reduced by using clear monofilament mesh	- positive (alternate choice to gill nets)
Gill Nets	$250/gang	minimal	- portable, simple to use, low cost - versatile, wide variety of applications - effectiveness varies with net design and construction - most cost effective gear listed	- size selection varies with mesh size - fish seldom captured unharmed - catches all sizes, numbers and species of fish	- labour intensity directly related to number of fish caught	- fish seldom caught unharmed - visibility may be reduced by using clear monofilament mesh	- positive
Dip Nets	$30	minimal	- best suited when fish concentrated in large numbers in shallows, eg, as during spawning - high success under proper conditions	- this collection method is entirely dependent on the the ability of collector to see target fish; therefore limited to water of good clarity - site accessibility due to bottom type or depth - limited reach of net - fish learn to avoid net	- minimal cost/sample under optimal conditions - variable success	- best suited for use over spawning grounds - minimal application under other conditions	- positive (limited application)
Beach Seines	$300	minimal (requires site selection)	- best suited for shallow, clear beaches - gear should be used in determining variety, rather than actual numbers of fish - recommended that minnow traps be used in conjunction with beach seining	- maximum depth to which gear is effective is equal to the wing height of the net - careful site selection (ie, bias) required for use - selects against larger and quicker fish	- 5 to 20 minutes haul depending on length of net and amount of weed present in area sampled	- limited sites available for deployment - best suited as a qualitative indicator of species present rather than a quantitative measure - should be used in conjunction with minnow traps	- negative (may have limited application in specialized situations)
Purse Seines/ Other Trawls	$200-$5000	1/2 - 1 h/site	- best suited for large numbers of fish swimming in open waters at moderate depth	- selects against larger and quicker fish - requires large areas of open water and clean bottom for proper operation	- labour intensive, time consuming cumbersome and moderate to high equipment costs	- lake bathymetry not suited for these types of gear - not readily portable	- negative

summarized. A subjective opinion as to the suitability of the gear type to the study area is included. Based on this summary electroshocker, gill nets, trap nets and trammel nets were selected for testing in this study.

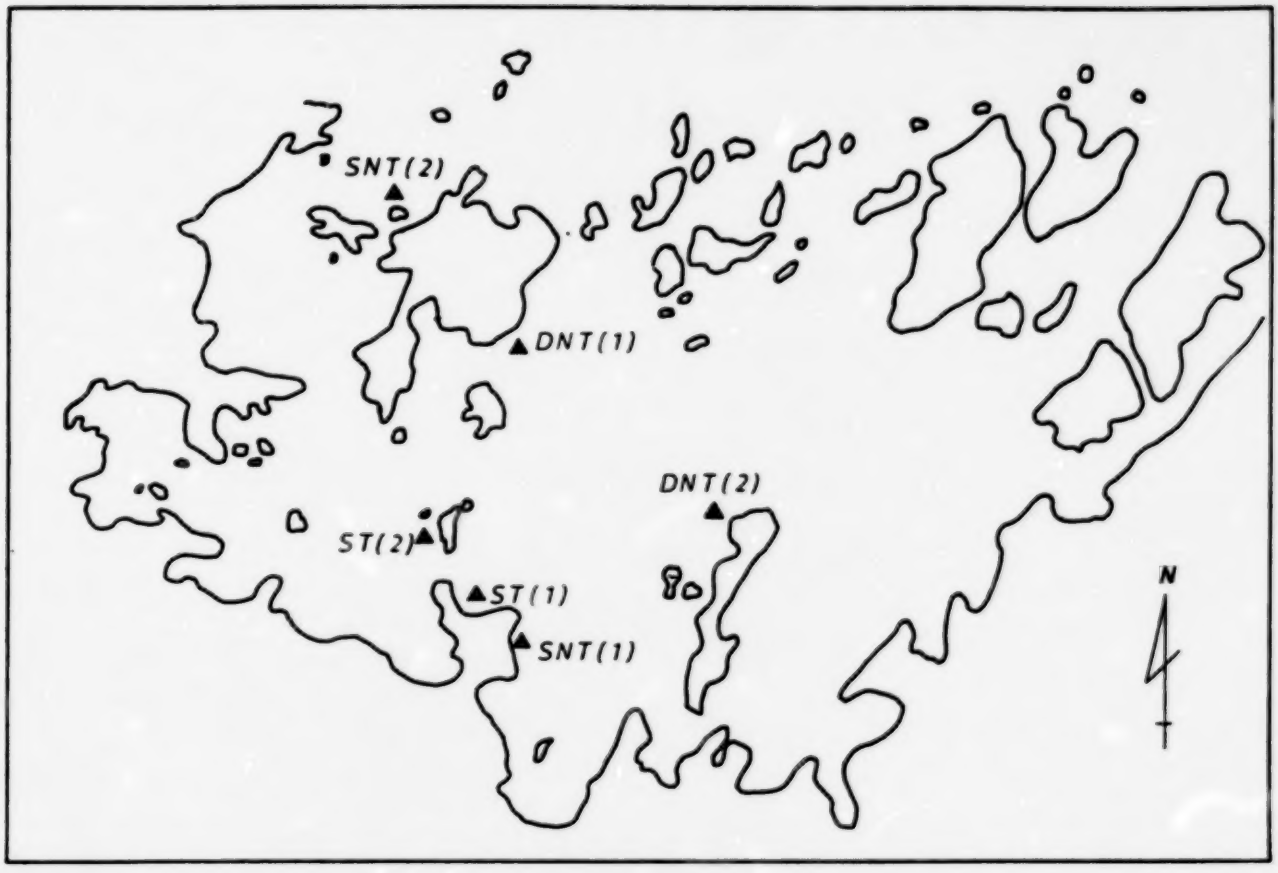
METHODS

Comparative tests of the fishing gear were conducted in the area of Anderson Dam (Figure 1) during 1981 and 1982. Three sampling environments were studied in duplicate; shallow no trees (SNT), deep no trees (DNT) and shallow with trees (ST), for a total of six sampling locations (Figure 1). In August 1981, 1.2 m trap nets were set at these sites for 24 h periods, with either a full- or half-length lead line attached. Half-length leads were used as the lake bottom dropped off quickly at a few of the locations. Catch was recorded as numbers of fish caught in the trap, as well as numbers of fish caught in the lead. Fish gilled in the lead were counted as dead. A trial electroshocking run was also conducted in the drained basins of Moose Lake as well as in the vicinity of Anderson Dam. In August of 1982, trammel and gill nets were substituted for trap nets. These were set at the same locations as were the trap nets in 1981. Fish catch was recorded and the numbers of live and dead fish were noted. Since the primary objective for fish capture was for tagging purposes, it was important that mortality should be held to a minimum. For this reason the lengths of the sets were limited to six hours for trammel nets and two hours for gill nets. The nets were set in the early evening and pulled at dusk, as boat operation in this area is hazardous after dark due to the large number of navigational hazards (trees, stumps and shoals) present. The length of the trammel net sets were increased to 18 hours when insufficient numbers of fish were being caught.

RESULTS AND DISCUSSION

The 1.2 m trap nets set in the 1981 experimental fishing program at Anderson Dam yielded a total of 74 fish of which only 70% were recovered alive (Table 2). Of these catches, only 55% of the walleye and 45% of the northern pike were alive. In all instances the number of walleye and northern pike gilled in the lead was greater than that caught in the trap. The numbers of pike and walleye caught were similar for both half and full-length lead trap nets.

The electrofishing results at the Anderson Dam experimental netting sites were disappointing as only one walleye and several yellow perch were caught. Although the electroshocker proved ineffective in the Anderson Dam area a trial electrofishing run was also conducted in the drained basins of Moose Lake. This effort yielded forty northern pike, five lake whitefish and one



SNT - Shallow, no trees
DNT - Deep, no trees
ST - Shallow with trees

FIGURE 1

ANDERSON DAM AREA OF MARMION LAKE
EXPERIMENTAL NETTING LOCATIONS

TABLE 2

RESULTS OF EXPERIMENTAL FISHING
ANDERSON DAM, 1981 AND 1982

	Shallow No Trees			Shallow With Trees			Deep No Trees			Total		
	Alive[1]	Dead[2]	CUE[3]	Alive[1]	Dead[2]	CUE[3]	Alive[1]	Dead[2]	CUE[3]	Alive	Dead	% Alive
Trap Nets 1981 (50 ft lead)												
Walleye	1	1	0.5	0	0	0.0	5	2	1.8	6	3	67
Northern Pike	2	0	0.5	1	2	0.8	1	1	0.5	4	3	57
White Sucker	1	0	0.3	0	0	0.0	1	0	0.3	2	0	100
Yellow Perch	3	0	0.8	2	0	0.5	2	0	0.5	7	0	100
NUMBER OF SETS	4			4			4			12		
Trap Nets 1981 (100 ft lead)												
Walleye	2	2	1.0	1	1	0.5	2	4	1.5	5	6	45
Northern Pike	3	6	1.3	1	0	0.3	1	2	0.8	5	8	38
White Sucker	6	0	1.5	1	1	0.5	5	1	1.5	12	2	86
Yellow Perch	8	0	2.0	3	0	0.8	0	0	0.0	11	0	100
NUMBER OF SETS	4			4			4			12		
Gill Nets 1982												
Walleye	3	0	1.2	0	1	0.8	2	0	0.9	5	1	83
Northern Pike	1	0	0.4	0	1	0.8	1	0	0.4	2	1	67
White Sucker	2	0	0.8	0	0	0.0	2	0	0.9	4	0	100
Yellow Perch	1	1	0.8	0	0	0.0	0	0	0.0	1	1	50
NUMBER OF SETS	2			1			2			5		
Mean Duration (h)	2.7			2.5			2.5			2.6		
Trammel Nets 1982												
Walleye	0	0	0.0	0	1	0.2	0	0	0.0	0	1	0
Northern Pike	1	3	1.7	0	7	1.1	3	3	3.3	4	13	24
White Sucker	6	0	2.6	10	17	4.4	2	0	1.1	18	17	51
Yellow Perch	0	0	0.0	0	2	0.3	0	0	0.0	0	2	0
NUMBER OF SETS	2			2			2			6		
Mean Duration (h)	6.3			18.3			5.5			10.1		

[1] including those fish gilled in the lead of trapnets but recovered still alive
[2] all dead fish in trap nets were gilled in the lead
[3] based on unit of effort of 24 hours for trap nets, 2 hours for gill nets, and 6 hours for trammel nets

walleye. In Moose Lake fish were artificially concentrated in shallow pools when the water level of the Lake was lowered approximately 20 m during the construction of the intake tunnel; however, these results emphasize the usefulness of electroshocking as a fishing technique in shallow, constricted bodies of water or in areas where fish are concentrated as opposed to open lake situations. Fish mortality during electroshocking was negligible.

In 1982, trammel and gill nets were set in the same locations as were the trap nets in 1981. The trammel nets caught more fish due to the duration of the sets but were less effective than gill nets in catching walleye. This difference may be partially attributed to the higher visibility of the trammel net in the water due to the large amount (as compared to a gill net) of mesh used in its construction. This factor may be minimized by using clear monofilament nylon instead of the white multifilament nylon presently used in both the trammel and gill nets.

Initially the trammel nets were set for six hour periods, but when it became apparent that insufficient numbers of fish were being caught, the length of the set was increased to 18 hours to include the overnight period in which most of our target fish are most active. More fish were subsequently caught, but by the same token, mortality had increased (Table 2). The greater mortality rate for the trammel net in comparison to that of the gill net cannot be solely attributed to differences between gear types, as the gill nets were pulled after only two hours, but inherent differences in the construction of the trammel net undoubtedly contributed to this high mortality. At the inception of the 1982 experimental netting program it was believed that the trammel net would be less harmful to the fish than a gill net, thus permitting us to fish for longer periods of time (ie, overnight). However, during the course of this study it was found that northern pike, walleye and other species of fish would "roll" in the loosely hung central mesh and, as a result, would suffocate. It was also considerably more difficult and time consuming to extract a fish (ie, greater fish handling) from a trammel net due to the large amount of mesh in which the fish was entwined. For these reasons, trammel nets do not seem to be an appropriate gear type for use in further studies in the Atikokan area.

Because of low catches, short-set gill nets were substituted for trap nets for the second year of pre-operational studies at Atikokan in 1982. The pre-operational fish catch results for 1981 and 1982 are presented in Table 3. The short set gill nets caught an average of 5.7 fish per set as compared to 2.4 fish per trap net set. The catch per set for target species was also greater in the gill nets, especially in the number of coregonids

TABLE 3

COMPARISON OF PRE-OPERATIONAL FISH CATCH RECORDS
WITH 1.2 m TRAP NETS AND SHORT SET GILL NETS

Species	1.2 m Trap Nets 1981			Short Set Gill Nets 1982		
	Number*	Per Cent Composition	Catch Per Net	Number	Per Cent Composition	Catch Per Net
Walleye	112	24	0.6	42	12	0.7
Northern Pike	178	37	0.9	62	18	1.0
Lake Whitefish	3**	1	0.0	59	17	1.0
Cisco	28**	6	0.1	70	20	1.2
White Sucker	106	22	0.6	92	27	1.5
Yellow Perch	39	8	0.2	19	6	0.3
Burbot	9	2	0.0	1	0	0.0
Pumpkinseed	2	0	0.0	0	0	0.0
TOTAL	477		2.4	345		5.7
NUMBER OF SETS			188			60

* including those gilled in the lead

** all gilled in leads

caught. In terms of cost effectiveness, these results favour the use of gill nets over trap nets. These results serve only as an indication of gear type effectiveness as yearly fluctuations in the population size of the various fish species must be considered.

As noted earlier, the target species are generally more active after dusk and, as such, netting efforts should be conducted during this same period. As navigational hazards limit the number of sampling sites accessible after dark, nets would have to be set overnight, which would increase the mortality in our catch. Sites in the Atikokan sampling area which could be fished in relative safety after dark are: Anderson Dam (area DNT(1), Figure 1), Snow Lake, Icy Lake and possibly Slush and Moose Lakes. The remaining sampling sites are only safely accessible by water during daylight hours.

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LITERATURE CITED

Bartoo, N.W., R.G. Hansen and R.S. Wydoski, 1973. A Portable Vertical Gill Net System. Prog. Fish Cult. 35(4): 231-233.

Backiel, T. and R.L. Welcomme (eds.), 1980. Guidelines for Sampling Fish in Inland Waters. EIFAC Tech. Pap. (33): 176 p.

Bernhardt, J.W., 1960. Effect of Fyke-Net Position on Fish Catch. N.Y. Fish and Game Journal 7(1): 83-84.

Brege, D.A., 1981. Growth Characteristics of Young-of-the-Year Walleye in John Day Reservoir on the Columbia River, 1979. Fish Bull. 79(3).

Craig, J.F., 1980. Sampling with Traps. EIFAC Tech. Pap. (33): 55-70.

Dadswell, M.J., 1975. A Small-Boat Otter Trawl for Limnological Studies. J. Fish Res. Board Can. 32: 2535-2538.

Dahm, E., 1980. Sampling with Active Gear. EIFAC Tech. Pap. (33): 71-89.

Hamley, J.M., 1980. Sampling with Gill Nets. EIFAC Tech. Pap. (33): 37-53.

Hartley, W.G., 1980. The Use of Electrical Fishing for Estimating Stocks of Freshwater Fish. EIFAC Tech. Pap. (33): 91-95.

Houser, A. and A.W. Ghent, 1964. An Experimental Gill Net Based on the Principle of the Latin-Square. Trans. Am. Fish Soc., 93: 233-242.

Jester, D.B., 1973. Variations in Catchability of Fishes with Colour of Gill Nets. Trans. Amer. Fish Soc. 1973 (1): 109-115.

Kitchell, J.F., 1977. Percid Habitat: The River Analogy. J. Fish Res. Board Can. 34: 1936-1940.

Maloney, J.E. and H. Johnson, 1955. Life Histories and Inter-Relationships of Walleye and Yellow Perch, Especially During the First Summer in Two Minnesota Lakes. Trans. Am. Fish Soc. 85: 191-202.

MacKay, H.H., 1963. Fishes of Ontario. Ontario Department of Lands and Forests.

Marshall, T.R., 1977. Morphological, Physiological and Ethological Differences Between Walleye and Pike Perch. J. Fish Res. Board Can. 34: 1515-1523.

Ontario Ministry of Natural Resources Publication, 1980. Manual of Instructions for Aquatic Habitat Inventory Surveys. Fisheries Branch. 159 p.

Ryder, R.A., 1977. Effects of Ambient Light Variations on Behaviour of Yearling, Sub-Adult and Adult Walleye. J. Fish Res. Board Can. 34:1481-1491.

Scott, W.B. and E.J. Crossman, 1973. Freshwater Fishes of Canada. Bull. 184. Fish Res. Board Can. 966 p.

Stott, B., 1970. Some Factors Affecting the Catching Power of Unbaited Fish Traps. J. Fish Biol. 2: 15-22.

United States Environmental Protection Agency, 1973. Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents. Edited by C.I. Weber.

APPENDIX 1

CHARACTERISTICS OF TARGET SPECIES

Cisco (Coregonus artedii)

The cisco inhabits the clear, cold waters of most deep inland lakes. It is a pelagic species forming midwater schools whose depth distribution is dependent upon the water temperature, season and oxygen levels. MacKay (1963) found that the depth distribution of cisco could be related to the trophic status of the lake as cisco require an abundant source of oxygen such as may be found in deep infertile lakes, as opposed to a deficiency in oxygen at mid-depth in fertile lakes. During the summer months the cisco migrate below the thermocline (oxygen levels permitting) and distribute themselves throughout the hypolimnion. Cisco are predominantly near-bottom feeders on plankton, but when in shallow waters (ie, spring and fall) aquatic insects make up 90% of their diet. During late August and early September, the cisco return to the shallow waters. Scott and Crossman (1973) have related this movement to the increase of carbon dioxide and subsequent decrease in oxygen levels in bottom waters which occur by this time of year.

Spawning takes place in late November in 1 to 3 m of water over sandy or gravelly shoals in areas free of weeds. Peak spawning activity occurs as water temperatures fall below 4°C. Lake Nipissing cisco spawn at an age of 3+ (at a length of 25.5 cm) and most cisco are capable of spawning at four years of age. Eggs hatch in late April to early May. As with other species, females tend to grow and live longer than males. Commercially, large trap nets and gill nets are set on the bottom to catch cisco which are most readily caught during the fall spawning aggregation.

Lake Whitefish (Coregonus clupeaformis)

The lake whitefish is a cool water species, moving from deep to shallow waters in the early spring and back to deeper waters as warming occurs. By the end of May, whitefish are rarely found in shallow waters and do not reappear until late October or November. Spawning takes place in late November in the Great Lakes, but occurs as early as late September in more northerly locations. Spawning takes place as temperatures fall below 7.8°C (Scott and Crossman, 1973) and occurs in shallow waters after sunset.

Adults are generally bottom feeders on small molluscs, aquatic insect larvae, chironomid larvae and planktonic crustaceans.

Burbot and suckers are important competitors of the whitefish for certain items in their diet. Lake whitefish are caught commercially in large trap nets.

Northern Pike (Esox lucius)

The habitat of the pike is usually in clear, warm, slow moving, heavily vegetated rivers or warm, weedy bays of lakes. They generally occur in shallow waters in the spring and fall, moving into deeper, cooler waters at the height of summer. According to Scott and Crossman (1973) northern pike, especially the young, are usually taken in the top 5 m of water, but have been captured as deep as 100 ft in late summer at Lake Nipigon, Ontario. Northern pike are continual wanderers in small lakes of uniform habitat conditions (MacKay, 1969), but in general, northern pike are fairly sedentary, establishing vaguely defined territories where cover and food are adequate. Pike are known to return year after year to the same spawning areas (MacKay, 1969; Scott and Crossman, 1973). Spawning takes place immediately after ice-melt in April or early May when water temperatures are 4.4-11.1°C. Spawning takes place during the day on shallow (10-45 cm) heavily vegetated flood plains of rivers, marshes or bays of larger lakes. The actual size of suitable spawning areas available to the pike may be a limiting factor in the total number of pike present in the lake.

Walleye (Stizostedion vitreum vitreum)

Walleye thrive in cool lakes and rivers, especially where there are extensive forage and spawning areas. Walleye are negatively phototropic and as such, according to Ryder (1977), light is the principal abiotic controlling variable of the environment which determines the temporal and spatial dimensions of feeding and reproduction in the walleye. Walleye avoid high light intensities by: a) swimming to deeper water and using the vertical stratum of water as a light filter, b) swimming to a more turbid (and usually more turbulent) portion of the lake, or c) by remaining in shallow water and utilizing some sort of shelter such as boulders or weed beds. While walleye make use of all three methods to avoid high illumination levels, the latter method is more commonly employed, providing that shelter is readily available. Ryder (1977) utilizing SCUBA found that most (98%) of the walleye he observed were found over a boulder substrate rather than other types of substrate, and in areas where there was a slight perceptible current. Also, all "resting" fish appeared to be "sleeping" with their ventral regions in direct contact with the substrate or with submerged macrophytes. Little active swimming was observed during daylight

hours except in areas of high turbidity or low levels of illumination. Carlander and Cleary (1949) in Ryder (1977) reported that gill nets set in deep and shallow water in Lake of the Woods indicated not only more walleye movement at night, but also a shoreward movement of the fish into the shallows, presumably to feed. They also reported that during two days of dark skies and rainshowers there was a corresponding increase in the numbers of walleye captured.

Kitchell (1977) further defined the walleye habitat as that of the sublittoral during periods of high light intensity and/or thermal stratification. In thermally stratified lakes, the habitat may be bounded by the intersection of the thermocline and the substrate. During summer stratification the lower depth limit approximated by the thermocline is very sharp in small systems, but less defined in large lakes.

Walleye spawn shortly after ice-out at water temperatures of 5.6-11°C. Spawning occurs at night as large numbers of walleye congregate over boulders or coarse gravel shoals in the moving water below falls, dams or narrows. The eggs hatch in 12-18 days at prevailing water temperatures. By the end of the first growing season the young are 3-4" long (Scott and Crossman, 1973). In many small lakes, the requirement for suitable spawning areas may limit the actual numbers of walleye found in each lake. Kitchell (1977) studied the habitats of walleye and found many small populations of walleye present in numerous small lakes, but only large populations in those small lakes which were connected to another body of water such as a river or larger lake system.

Walleye are a highly opportunistic and pisciverous fish. Maloney and Johnson (1955) found a close association between young of the year walleye and yellow perch. The differences in their growth rates and feeding habits has led these researchers to suggest that the size of the yellow perch crop may be a factor in determining the year class strength of the walleye.

APPENDIX 2

DESCRIPTION OF FISHING GEAR TYPES

Active Gear

Active gear types are those which are actively moved through the water column, and include such gear as beach seines, electro-shockers, purse seines, trawls and other similar devices. Their advantage is that a calculated volume of water may be sampled and that, given favourable conditions, a large sample size may be collected in a relatively short period of time. The main disadvantage of these systems, however, lies with the actual deployment of the gear. For best results the bottom morphology of the lake should be hard, debris-free, and gently sloping. This is the complete opposite of those conditions encountered at the Atikokan study area. Steep slopes, shoals and bottom debris (trees and stumps) would adversely affect the efficiency of such gear due to snagging, rolling and clogging. Another major disadvantage is that such gear requires long stretches (minimum 600 m or 10 ha/haul) of open water to tow through for any appreciable length of time (Dahm, 1980).

Beach seines while effective in catching small, slow moving fish, still require the selection and/or preparation of a suitable shoreline for seining. Seining is not an effective sampling method in areas which have snags or sunken debris, nor is it effective in deep water as the fish may escape over the floats and under the lead line. The maximum depth which may be fished by any such encircling net is limited to the wing height of the net. Seining or encircling, in general, selects against the larger and more active fish as their avoidance reaction is generally quicker than the speed with which the net is pulled. Although the results are often expressed as numbers of fish caught per unit area seined, quantitative seining is very difficult. This method is more useful in determining the variety, rather than the number of fish inhabiting the water. The use of minnow traps set for varying periods of time instead of, or in conjunction with beach seines would probably yield a more representative selection of species from the shallower waters.

Purse seines are most effective for schooling fish swimming near the surface. The size selection of the gear is dependent mainly on the speed of hauling, as the larger and generally quicker fish may avoid the net. Major disadvantages of the net involve the size of the net, equipment requirements of large boats with heavy winches, and a cost of approximately twenty times that of a conventional trawl.

A small (2.5 x 5.5 m) otter trawl as described by Dadswell (1975) for use in inland lakes would again not be suitable for the lakes of the morphology of those found in the Atikokan

area. Lakes of rapidly changing bathymetry would pose an additional problem as the depth of the tow net could not be easily adjusted once the tow is under way. Trawls must be towed at sufficient speeds so as to overtake and enclose any fish in its path. Such a collection system for tows less than one kilometer long would be very labour intensive, time consuming and cumbersome.

Electrofishing

Hartley (1980) defined electrofishing as a general term which covers a number of different methods which all have in common the use of an electrical current flowing through the water to impress upon the fish within the space affected a common pattern of reaction leading to their capture.

The extent of the controlling field depends upon the power of the unit, water conductivity, water temperature and the efficiency of the type of current used as a stimulator. The degree of stimulation depends on the difference in electrical potential between the fish's head and its tail. This physical factor introduces bias towards the capture of larger fish. Furthermore, the size of the controlling zone is limited (usually <2 m) and associated with it is an even larger zone which the fish may sense and avoid. This is especially true for larger fish as they will be more sensitive to the electrical field. In a closed system, sampling error is increased by "fugitive" fish (Hartley, 1981), which are those fish which had been previously shocked and captured, and have since learned to avoid an electrical field at the first sensation.

The advantages of electrofishing are: a) there is no site preparation required, b) manpower and equipment requirements are manageable, c) large areas may be covered in a relatively short period of time, and d) it may be useful in stunning fish "hiding" underneath logs and boulders (eg, walleye). The disadvantages include: a) variability of effect due to physical conditions, b) variability of effect on different fish species, c) variability of effect due to experience of operators, d) risk of injury to both fish and operators, e) systems are rarely effective at depths greater than 2 m (unless equipment is modified) and d) electroshockers are least effective in pond situations where the fish may escape in three dimensions. However, electroshockers are most effective in narrow situations where a current is present as a collecting net may be set up downstream to catch the drifting, stunned fish. This may provide an ideal way of collecting such fish as walleye for tagging studies, as walleye congregate in such areas during spawning. Caution is advised however, as the behavioural and physiological effects of electroshocking on spawning fish and their eggs is not known.

Dip Nets

Hand-held or pole mounted dip nets are useful in collecting slow-moving fish in shallow waters. Greatest success of capture has occurred during spawning periods when fish congregate in large numbers in the shallows. Personal experience on walleye spawning grounds has proven this method to be an effective way of capturing walleye for tagging. Unfortunately, the walleye became aware of the net after about fifty minutes and avoided the net thereafter. Other limitations of this system include: limited reach of the net and accessibility to the collection site due to currents, water depth and bottom debris.

This collection method is entirely dependent upon the ability of the collector to see the fish in the water and, as such, sampling is limited to waters of good clarity and little turbulence.

In summary, active gear types are severely restricted in their application in small inland lakes of the bathymetry of those found in the Atikokan study area. Their use in these lakes should be limited to that of dip nets, electroshockers and small beach seines in selected locations.

Passive Gear

Passive gear types are those which are stationary and depend upon the fish swimming into or becoming entangled in the actual net or trap. Passive gear types include trap nets, hoop and fyke nets, Windermere traps, as well as gill and trammel nets.

Traps

A trap is a passive fishing gear which is stationary, and relies on the movement of fish into the trap for capture. Traps are most effective in areas of little or no natural cover, and in such areas the fish may use these traps as a form of cover or refuge.

As with other forms of fishing gear, the various forms of traps have inherent advantages and disadvantages. The advantages of traps are:

a) Traps are relatively inexpensive to purchase and operate.
b) They can be used in a wide variety of situations.
c) The fish captured are usually unharmed.
d) The trapping efficiency for certain species of fish may be enhanced by baiting.

The disadvantages of traps are:

a) They are highly selective for species and sizes of fish.

b) Trap net catches are strongly influenced by seasons (Craig 1975, Leopold 1975).
c) Catches may (Stott, 1970) or may not (Craig, 1974) be influenced by water temperature.
d) In some situations, submerged and emergent vegetation must be cleared before the nets will fish effectively.

Traps are highly selective for species and size of fish. The mesh size determines the lower length limit of the fish trapped, whereas the size of the funnel entrance determines the upper size limit. Craig (1974) found wire mesh traps with 0.64 cm mesh trapped perch from 5 cm and those of 1.28 cm caught fish from 9.5 cm.

Trap Nets

Latta (1959) in Hamley (1975) found that trap nets were selective for different species and, depending on mesh size, did not adequately sample smaller fish. He also found that trap nets are seasonally selective with the greatest number of fish being caught during the spring spawning season. Bernhardt (1960) reported that fyke nets, which operate on the same principle as trap nets, would on the average catch more fish if set parallel to the bottom contours, than in nets set perpendicular to shore.

Hoop and Fyke Nets

Hoop nets are conical fish traps made of mesh stretched around round frames and having two funnel-shaped openings in series. Hoop nets vary in size but usually consist of six or seven hoops of decreasing diameter from 1.6 m at the entrance to 0.6 m towards the cod-end.

A fyke net is basically a hoop net with wings and a leader mesh attached. In moving water, where spawning fish are swimming upstream, the mouth of the net is positioned downstream and the cod end upstream. Fyke nets are very species specific with the greatest capture success being with eels. Bernhardt (1960) reported that a fyke net, set parallel to the bottom contours, will on the average catch more fish than one set perpendicular to shore. Fyke nets have been used successfully in Poland in commercial fisheries for pike, perch, roach and rudd.

Windermere Traps

Windermere traps are also used extensively as they are portable and relatively inexpensive in terms of both cost and labour. However, the size of the fish captured is dependent upon the

size of the opening. Windermeres should be made of nylon mesh so as to avoid corrosion, distortion in the shape of the net and to prevent injury to the fish and the fish handler.

The addition of wings and leaders to Windermeres does not improve the efficiency of the traps, but covering the traps with brush and black plastic decreases the traps' effectiveness (Beall and Wahl, 1959). Various authors have used such bait as cottage cheese and soybean cake to significantly enhance their catches. This practice, however, leads to serious questions regarding the validity of the data in respect to population estimates.

Gill Nets

Gill nets are a very popular form of sampling gear as they are versatile, low in cost, easy to operate and adaptable to many situations. The disadvantages of gill nets are that: a) they seldom take fish unharmed, b) they capture large numbers of unwanted fish species, c) each mesh size catches fish of only a narrow size range, d) the amount of gill netting effort cannot be related to the volume of water fished as with active gear types, and e) larger mesh sizes are generally more efficient than smaller meshes.

Gill nets are made in a wide variety of sizes, colour, twine material and thickness, hanging and rigging of floats and weights. All of these variables have an effect on the efficiency and selectivity of the net. In general, commercial gill nets are designed for high selectivity for certain species and size ranges (thus minimizing catches of unwanted species or unmarketable sizes), while research nets are often designed to sample for all sizes and species of fish (ie, low selectivity).

Choosing the appropriate mesh sizes for gill nets for a given area or species is difficult to predict. The best guide is to go by those types of nets proven to be successful in the past. The efficiency and selectivity of a given gill net is a function of its design and its construction. The size of the mesh chosen needs to be matched to the species and size of the fish desired. If no previous data are available, length-girth data may be used, as discussed in Hamley (1980).

Optimum size: According to many authors, the optimum girth for capture is about 1.25 times the mesh perimeter (range 1.08 to 1.35 times), and the optimum length increases approximately in proportion to mesh size.

Selection range: According to Baranov's (1948) rule of thumb, in Hamley (1980) fish more than 20% longer or shorter than the optimum length are seldom caught.

Gangs of gill net panels of varying mesh sizes tied end to end are an attempt to catch fish of all sizes in their naturally occurring proportions. The mesh sizes of the panels comprising the gang of gill nets are chosen such that the sum of the selectivity curves of each panel approximates a straight line when plotted. This hypothetical line is seldom achieved as: a) larger mesh sizes are more efficient and have a larger selectivity curve than do smaller meshes (therefore the length of the large-meshed panel should be proportionately shorter than the small mesh), and b) most mesh sizes have selectivity curves which are species specific, so that nets designed to be non-selective for one species may not be so for another species.

Other than mesh size, the next most important characteristics of a gill net are its visibility, stretchability of meshes and its tangling capacity. These characteristics affect first the avoidance behaviour of the fish and, second, the probability of catching fish that swim into the net.

Visibility: Most commonly, net avoidance depends on sight. Nets made up of monofilament are less visible that those made of other materials and, therefore, are usually more successful. Larger fish may be better able to see the nets as visual sensitivity and acuity may improve as a fish grows.

With regard to variations in catchability of fishes with colour of gill nets, Jester (1973) found that all colours of gill net afforded positive or negative selectivity for various species. The most significant differences (when compared to nets made of white nylon) were reduced catches in the coloured nets. The use of coloured nets theoretically would allow for the selection of target species, while minimizing the catch and numbers of unwanted species. Unfortuantely, none of the colours tested had any direct bearing on the four target species we are concerned with (ie, cisco, lake whitefish, walleye and northern pike). The only applicable consideration is between the use of white nylon and clear monofilament nylon mesh. Jester (1973) stated that seasonal differences in catch rates between coloured and white nets were found only in clear monofilament nets. Catch rates in monofilament nets were higher than in white nets during summer when water transparency was low ($X = 0.735$ m), and higher in white nets from September through March when water was relatively clear ($X = 1.045$ m). Jester observed that monofilament nylon appeared to break light into a spectrum, which was found to be more intense and visible when water was clear than when plankton was absorbing light and shading the nets.

Material: The material which makes up the net twine affects the probability of holding fish that have swum into the net. The least effective material is linen, followed by cotton, multi-

filament nylon and finally monofilament nylon. As the material becomes more elastic and flexible, the number of fish tangled increases, which broadens the selection range as the size of a tangled fish depends less on mesh size than does the size of a wedged fish. Meshes of a more elastic twine can also be stretched to a larger size by a struggling fish. Small fish may be too weak to stretch the twine.

Thickness: Nets of thinner twine are less visible, easier to stretch, and more flexible; therefore,they should tangle more and larger fish as long as the twines are not broken by those larger fish.

Net construction: Various aspects of net construction affect its ability to fish. Loosely hung nets tangle more fish as is demonstrated by Riedel's (in Hamley 1980) catches of Tilapia (Tilapia mossambica) with 10 cm mesh gill nets of three different hanging coefficients. (Hanging coefficient gives the ratio of the length of completed net to the streched length of webbing used in it.)

Hanging Coefficient	Avg # Caught Per Day	Per Cent Tangled	Size Range of 95% of Catch (cm)
1:1	9.3	0	18 - 23
1:2	29.5	24	13 - 23
1:3	81.0	80	8 - 22

Because tangling is not as selective as wedging or gilling, loosely hung nets caught Tilapia of a much wider size range. Net hanging is important to captures by tangling, but has little effect on catches of fish such as roach that are usually caught wedged or gilled.

Besides the actual type of net used, the deployment and handling of the nets as they are sampled also affects the efficiency of the net.

Method of fishing: Care must be taken when pulling the nets into the boat that fish don't drop out of the net. An example is given by Farren (in Hamley 1980) in that large herring are often meshed loosely by the head and fall off easily; an increased proportion of them can be landed by hauling the net so that the side with the most herring is on top. An excellent discussion on the deployment and proper use of various gear types is given in the Procedures Manual issued by the Ontario Ministry of Natural Resources (1980).

Saturation: Von Brandt (1955) (in Hamley 1980) studied the effects of catch saturation, and found that catches do not accumulate at a uniform rate and that net efficiency decreases as fish accumulate in it. Eventually the number of fish in the net reaches a saturation level beyond which catch does not increase any further. As an example, Von Brandt cites that in a very good catch of herring, only 1.7% of the meshes (in a drift net) are actually occupied by fish.

Interaction of nets: Bias may be introduced in nets tied end to end in a single gang. Certain positions in the gang may be more favourable than others; the catch in one net may be reduced by competition with an adjacent more efficient net; and large fish may "lead" along a small meshed net. If nets must be set in gangs, leading may be minimized by leaving gaps between the nets, however it is best to set different meshed nets at separate, randomly chosen positions far enough apart that they do not compete for capture of the same fish. The randomized mesh size distribution approved by the Ontario Ministry of Natural Resources (1980) is:

6.4 - 11.4 - 3.8 - 8.9 - 5.1 - 10.2 - 7.6 - 12.7 cm

(2.5 - 4.5 - 1.5 - 3.5 - 2.0 - 4.0 - 3.0 - 5.0 inches)

The Latin-square arrangement as proposed by Houser and Ghent (1964) consists of gill net panels of varying mesh size set in a radial pattern. This supposedly allows for sampling of all fish of different sizes in a small area, as well as eliminating any introduced bias due to the position of a given mesh size in a gang of gill net panels. Its usefulness as a collection system is questionable in lakes of steep and rapidly changing bathymetry. The deployment and handling of the nets in such a pattern also becomes considerably more difficult and time consuming.

Gill nets are sometimes set vertically through the water column in an attempt to study the depth distribution of fish. A suitably portable, vertical gill net system is described by Bartoo et al (1973).

Trammel nets are modified gill nets which consist of three walls. Fish can swim through the large (eg, 8") outer mesh without obstruction, push part of the loose, small-meshed (eg, 2") central mesh through the third outer large mesh and, in doing so, the fish is caught in the pocket which is formed. Trammel nets should theoretically be less harmful to the captured fish, but during the course of this study it was found that pike, walleye and suckers tended to roll in the loosely

hung central mesh and become hopelessly tangled and suffocate in the net. Due to this tangling, the removal of a fish from the trammel net usually requires two pairs of hands and considerably more time than does removal from a gill net.

A summary of the various pertinent types of gear discussed in this report is listed in Table 1. The cost, preparation time, effectiveness, limitations and suitability of the various gear types in relation to the target species in the Atikokan area is summarized. A subjective opinion as to the suitability of the gear type to the study area is included.